CHAPTER 7

Establishing Airport Noise Compatibility Policies

Overview

This chapter examines the manner in which airport noise data—measured by means of the metrics and techniques discussed in Chapter 6—can be applied to establishment of land use compatibility policies. The guidance offered here places heavy reliance upon cumulative noise exposure metrics—specifically, the Cumulative Noise Exposure Level (CNEL)—as the principal gauge against which to assess the noise compatibility of land uses near airports. With regard to setting the specific criteria for compatibility, established federal and state regulations and guidelines provide the policy foundations. Also explicitly recognized, though, is the need to take into account the characteristics of individual airports and the communities which surround them when setting local noise compatibility policies. In particular, strong support is given to the concept of *normalization* as guidance for the policy-setting process.

Specific topics addressed in this chapter include:

- Federal and state noise policies;
- The effects of noise on people;
- Preparation of noise contours for compatibility planning purposes;
- Determining acceptable cumulative noise exposure levels;
- The relevance of single-event noise levels; and
- Other measures of noise compatibility

Noise Policy Foundations

Statutes enacted by the U.S. Congress and the California State Legislature typically set general requirements and the authority for administrative adoption of more detailed regulations and policies. With respect to airports, most of the administrative actions are taken by the Federal Aviation Administration and the California Department of Transportation, Division of Aeronautics. These statutes and regulations establish the basis for local development of airport plans, analyses of airport impacts, and enactment of compatibility policies. Brief descriptions of selected statutes, regulations, and policies having particular significance to noise issues are provided in the paragraphs which follow.

Federal Statutes and Regulations

Statutes

- **Aviation Safety and Noise Abatement Act of 1979 (ASNA)**—Among the stated purposes of this act is "to provide assistance to airport operators to prepare and carry out noise compatibility programs." The law establishes funding for noise compatibility planning and sets the requirements by which airport operators can apply for funding. The law does not require any airport to develop a noise compatibility program—the decision to do so is the choice of each individual airport proprietor. Regulations implementing the act are set forth in Federal Aviation Regulations Part 150.
- **Airport and Airway Improvement Act of 1982 (AAIA)**—This act established the Airport Improvement Program (AIP) through which federal funds are made available for airport improvements and noise compatibility planning. The act has been amended several times, but remains in effect as of late 2001.
- **Airport Noise and Capacity Act of 1990 (ANCA)**—In adopting this legislation, Congress' stated intention was to try to balance local needs for airport noise abatement with national needs for an effective air transportation system. To accomplish this objective, the act did two things: (1) it directed the FAA to establish a national program to review noise and access restrictions on aircraft operations imposed by airport proprietors; and (2) it established requirements for the phase-out of older model, comparatively louder, "Stage 2" aircraft from the nation's airline fleet by January 2000. These two requirements are implemented by Federal Aviation Regulations Part 161 and 91, respectively.

Federal Aviation Administration Regulations and Policies

In July 2000, the Federal Aviation Administration published a draft update of the 1976 policy. The proposed policy "reaffirms and incorporates the major tenets" of the 1976 policy. The policy continues to define areas of "significant noise exposure" as locations where noise levels are DNL 65 dB or higher. However, the policy goes on to indicate that the FAA will support local efforts to establish noise buffers outside this boundary of significance. As of late 2001, the draft policy remains under review.

- **U.S. Department of Transportation Aviation Noise Abatement Policy**—Adopted in 1976, this policy sets forth the noise abatement authority and responsibilities of the federal government, airport proprietors, state and local governments, the air carriers, air travelers and shippers, and airport area residents and prospective residents. The basic thrust of the policy is that the FAA's role is primarily one of regulating noise at its source (the aircraft) plus supporting local efforts to develop airport noise abatement plans. The FAA will give high priority in the allocation of Airport Improvement Program funds to projects designed to ensure compatible use of land near airports. However, it is the role of state and local governments and airport proprietors to undertake the land use and operational actions necessary to promote compatibility.
- **Federal Aviation Regulations Part 36, Noise Standards: Aircraft Type and Airworthiness Certification**—This part of the Federal Aviation Regulations sets the noise limits which all newly produced aircraft must meet as part of their airworthiness certification. The methods by which aircraft noise levels are to be measured are specified as well. The regulations catego-

rize aircraft (except small, propeller-driven airplanes) into three groups—referred to as Stage 1, 2, and 3—according to the noise levels they produce. Comparable aircraft (those having similar gross weights and numbers of engines) meeting the Stage 3 standards are quieter than equivalent Stage 2 aircraft. However, a heavy Stage 3 aircraft may be noisier than a light Stage 2 aircraft. Also, Stage 3 technology provides only limited improvements over Stage 2 with respect to low-frequency noise.

The Part 36 regulations make no determination that new aircraft are acceptably quiet for operation at any given airport. Rather, the regulations are intended to establish national maximum aircraft noise-emission levels.

➤ **Federal Aviation Regulations Part 91, General Operating and Flight Rules**—This part of the Federal Aviation Regulations sets many of the rules by which aircraft flights within the United States are to be conducted. Rules governing noise limits are set forth in Subpart I. Within this subpart is a provision which mandated that all Stage 2 civil subsonic aircraft having a maximum gross weight of more than 75,000 pounds be phased out of operation within the United States by January 1, 2000. This provision implements the requirement set forth in the Airport Noise and Capacity Act of 1990.

➤ **Federal Aviation Regulations Part 150, Airport Noise Compatibility Planning**—As a means of implementing the Aviation Safety and Noise Abatement Act of 1979, the Federal Aviation Administration adopted these regulations establishing a voluntary program which airports can utilize to conduct airport noise compatibility planning. "This part prescribes the procedures, standards, and methodology governing the development, submission, and review of airport noise exposure maps and airport noise compatibility programs, including the process for evaluating and approving or disapproving these programs." Part 150 also prescribes a system for measuring airport noise impacts and presents guidelines for identifying incompatible land uses. Airports which choose to undertake a Part 150 study are eligible for federal funding both for the study itself and for implementation of approved components of the local program.

The noise exposure maps are to be depicted in terms of average annual Day-Night Average Sound Level (DNL) contours around the airport. For the purposes of federal regulations, all land uses are considered compatible with noise levels of less than DNL 65 dB. At higher noise exposures, selected land uses are also deemed acceptable, depending upon the nature of the use and the degree of structural noise attenuation provided.

The FAA allows use of Community Noise Equivalent Level (CNEL) contours for airports in California.

In setting the various compatibility guidelines, however, the regulations state that the designations:

> "…do not constitute a Federal determination that any use of land covered by the [noise compatibility] program is acceptable or unacceptable under federal, state, or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local

authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses."

As of this writing, several FAR Part 161 studies are under way, but only a few have been completed, and none are yet approved by the FAA.

- **Federal Aviation Regulations Part 161, Notice and Approval of Airport Noise and Access Restrictions**—This part of the federal regulations implements the Airport Noise and Capacity Act of 1990. It codifies the analysis and notification requirements for airport proprietors proposing aircraft noise and access restrictions on Stage 2 or Stage 3 aircraft weighing 75,000 pounds or more. Among other things, an extensive cost-benefit analysis of proposed restrictions is required. The analysis requirements are closely tied to the process set forth in FAR Part 150 and are more stringent with respect to the quieter, Stage 3 aircraft than for Stage 2.

Regulations and Guidelines of Other Federal Agencies

- **U.S. Environmental Protection Agency (EPA)**—A report published in 1974 by the EPA Office of Noise Abatement and Control continues to be a source of useful background information. Entitled *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, this report is better known as the "Levels Document." The document does not constitute EPA regulations or standards. Rather, it is intended to "provide state and local governments as well as the federal government and the private sector with an informational point of departure for the purposes of decision-making." Using Yearly Day-Night Average Sound Level (DNL) as a measure of noise acceptability, the document states that "undue interference with activity and annoyance" will not occur if *outdoor* noise levels in residential areas are below DNL 55 dB and *indoor* levels are below DNL 45 dB. These thresholds include an "adequate margin of safety" as the document title indicates.

- **Federal Interagency Committee on Urban Noise (FICUN)**—The product of this committee was a 1980 report entitled *Guidelines for Considering Noise in Land Use Planning and Control*. These guidelines were not intended to substitute for those of individual federal agencies, but rather serve to establish a common basis upon which agency standards can be developed. The report features a table indicating the compatibility or incompatibility of various land uses listed according to their standard land use code (SLUC). All land uses are considered compatible with noise levels less than DNL 65 dB. Beginning at that level, residential and certain other land uses are judged compatible only if adequate noise level reduction is provided by the structure.

- **Department of Housing and Urban Development (HUD)**—HUD guidelines for the acceptability of residential land use are set forth in the Code of Federal Regulations Title 24, Part 51, "Environmental Criteria and Standards." These guidelines parallel those suggested in the FICUN report: noise exposure of DNL 65 dB or less is acceptable; between 65 and 75 dB is normally acceptable if appropriate sound attenuation is provided; and above DNL 75 dB is unacceptable. The goal for interior noise levels is DNL 45 dB. These guidelines apply only to new construction supported by HUD grants and are not binding upon local communities.

➤ **Department of Defense Air Installations Compatible Use Zones (AICUZ) Program**—The AICUZ program was established by the Department of Defense in 1973 as an effort to protect the federal government's investment in military airfields. The current noise compatibility criteria (as set forth in the Code of Federal Regulations Title 32, Part 256) are basically the same as those indicated in the FICUN report and the FAA's Part 150 program. AICUZ plans prepared for individual airfields are primarily intended as recommendations to local communities regarding the importance of maintaining land uses which are compatible with the noise and safety impacts of military aircraft operations.

➤ **Federal Interagency Committee on Noise (FICON)**—Established in 1991, this committee's task was to review technical and policy issues related to airport noise impacts. A final report, issued the following year, addressed such topics as:

- "The manner in which noise impacts are determined, including whether aircraft noise impacts are fundamentally different from other transportation noise impacts;
- "The manner in which noise impacts are described;
- "The extent of impacts outside of Day-Night Average A-Weighted Sound Level (DNL) 65 decibels (dB) that should be reviewed in a National Environmental Policy Act (NEPA) document;
- "The range of Federal Aviation Administration (FAA)-controlled mitigation options (noise abatement and flight track procedures) analyzed; and
- "The relationship of the FAA Federal Aviation Regulations (FAR) Part 150 process to the NEPA process; including ramifications of the NEPA process if they are separate, and exploration of the means by which the two processes can be handled to maximize benefits."

One of the FICON conclusions was that there are no new noise descriptors or metrics of sufficient scientific standing to substitute for the DNL cumulative noise exposure metric. However, FICON acknowledged that there may be instances in which supplemental noise analyses using other metrics may be appropriate.

➤ **Federal Interagency Committee on Aviation Noise (FICAN)**—FICAN was formed in 1993 as a result of a FICON recommendation that a standing interagency committee be created for the purpose of facilitating research into aviation noise issues. Toward this end, the committee functions as a clearinghouse for federal noise research and development efforts. It also has produced several position papers and conducted various public workshops on specific aviation noise topics. FICAN itself does not conduct or fund noise research; neither does it establish policies of its own.

See the FICAN Internet web site (www.fican.org) for more information about the committee's activities.

FICAN member agencies include:

- U.S. Air Force
- U.S. Army
- U.S. Navy
- Federal Aviation Administration
- National Aeronautics and Space Administration
- National Parks Service
- U.S. Environmental Protection Agency
- Department of Housing and Urban Development
- Centers for Disease Control and Prevention.

State of California Laws, Regulations, and Guidelines

➤ **State Aeronautics Act**—Chapter 4, Article 3, Section 21669 of the State Aeronautics Act (Division 9, Part 1 of the California Public Utilities Code) requires the State Department of Transportation to adopt—to an extent not prohibited by federal law—noise standards applicable to all airports operating under a state permit.

➤ **California Airport Noise Regulations**—The airport noise standards promulgated in accordance with the State Aeronautics Act are set forth in Section 5000 et seq. of the California Code of Regulations (Title 21, Division 2.5, Chapter 6). The current version of the regulations became effective in March 1990.

An important factor to recognize about the Airport Noise Regulations is that their compatibility criterion is mandated for only a few (less than a dozen) airports which are declared to have a "noise problem." The regulations do not establish a mandatory criterion for evaluating the compatibility of proposed land use development around other airports. Section 5004 of the regulations specifically notes that: "It is not the intent of these regulations to preempt the field of aircraft noise limitation in the state. The noise limits specified herein are not intended to prevent any local government, to the extent not prohibited by federal law, or any airport proprietor from setting more stringent standards." As discussed later in this chapter, setting the threshold for land use compatibility lower than CNEL 65 dB is appropriate at many airports.

In Section 5006, the regulations state that:

> "The level of noise acceptable to a reasonable person residing in the vicinity of an airport is established as a community noise equivalent level (CNEL) value of 65 dB for purposes of these regulations. This criterion level has been chosen for reasonable persons residing in urban residential areas where houses are of typical California construction and may have windows partially open. It has been selected with reference to speech, sleep and community reaction."

In accordance with procedures listed in Section 5020, the county board of supervisors can declare an airport to have a "noise problem." As specified in Section 5012, no such airport shall operate "with a noise impact area based on the standard of 65 dB CNEL unless the operator has applied for or received a variance as prescribed in…" the regulations.

For designated noise problem airports, the "noise impact area" is the area within the airport's 65 dB CNEL contour that is composed of *incompatible* land uses. Four types of land uses are defined as incompatible:

- Residences of all types;
- Public and private schools;
- Hospitals and convalescent homes; and
- Churches, synagogues, temples, and other places of worship.

However, these uses are not deemed incompatible if any of several mitigative actions has been taken as spelled out in Section 5014. Among these measures are airport acquisition of an avigation easement for aircraft noise and, except for some residential uses, acoustical insulation adequate to ensure that the interior CNEL due to aircraft noise is 45 dB or less in all habitable rooms.

➤ **California Building Code**—California Code of Regulations, Title 24—known as the California Building Code—contains standards for allowable interior noise levels associated with exterior noise sources (*California Building Code*, 1998 edition, Volume 1, Appendix Chapter 12, Section 1208A). The standards apply to new hotels, motels, dormitories, apartment houses, and dwellings other than detached single-family residences.

The standards state that:

> "Interior noise levels attributable to exterior sources shall not exceed 45 dB in any habitable room. The noise metric shall be either the Day-Night Average Sound Level (L_{dn}) or the Community Noise Equivalent Level (CNEL), consistent with the noise element of the local general plan. Worst-case noise levels, either existing or future, shall be used as the basis for determining compliance with [these standards]. Future noise levels shall be predicted for a period of at least 10 years from the time of building permit application."

With regard to airport noise sources, the code goes on to indicate that:

> "Residential structures to be located where the annual L_{dn} or CNEL exceeds 60 dB shall require an acoustical analysis showing that the proposed design will achieve the prescribed allowable interior level. For public use airports or heliports, the L_{dn} or CNEL shall be determined from the airport land use plan prepared by the county wherein the airport is located. For military bases, the L_{dn} shall be determined from the facility Air Installation Compatible Use Zone (AICUZ) plan. For all other airports or heliports, or public use airports or heliports for which a land use plan has not been developed, the L_{dn} or CNEL shall be determined from the noise element of the general plan of the local jurisdiction.
>
> "When aircraft noise is not the only significant source, noise levels from all sources shall be added to determine the composite site noise level."

DEPT. OF TRANSPORTATION
GUIDANCE
Although the building code does not apply the CNEL 45 dB interior noise level standard to detached single-family residences, the Division of Aeronautics encourages communities to adopt this standard (or lower) for these uses. Many communities have done so as part of their general plan noise element policies.

➤ **General Plan Guidelines**—Section 65302(f) of the California Government Code (Title 7, Division 1, Chapter 3, Article 5), requires that a noise element be included as part of local general plans. Airports and heliports are among the noise sources specifically to be analyzed. To the extent practical, both current and future noise contours (expressed in terms of either CNEL or DNL) are to be included. The noise contours are to be "used as a guide for establishing a pattern of land uses…that minimizes the exposure of community residents to excessive noise."

Guidance on the preparation and content of general plan noise elements is provided by the Office of Planning and Research in its *General Plan Guidelines* publication (last revised in 1998). This guidance represents an updated version of guidelines originally published by the State Department of Health Services in 1976. Included in the document is a table

This second table appears later in this chapter as Table 7B.

indicating noise compatibility criteria for a variety of land use categories. Another table outlines a set of adjustment or "normalization" factors that "may be used in order to arrive at noise acceptability standards which reflect the noise control goals of the community, the particular community's sensitivity to noise…, and their assessment of the relative importance of noise pollution."

EFFECTS OF NOISE ON PEOPLE

A central consideration in setting noise compatibility policies is to understand the ways in which noise affects people.

Types of Effects

Noise, especially aircraft noise, affects people and their activities in varied and complex ways. Three principal types of effects can be identified: *physiological*, *behavioral*, and *subjective*.

➤ **Physiological Effects**—Physiological effects can be either temporary or permanent. Among the temporary effects are startle reactions and the effects of sustained sleep interference. Hearing loss is the most obvious permanent effect of noise. Research indicates that off-airport aircraft noise, even from the loudest aircraft, is not severe enough to produce permanent or even sustained (after the noise ceases) effects on hearing. Less is known about the nonauditory health effects of aircraft noise. Despite new research conducted over the last two decades, a U.S. Environmental Protection Agency conclusion in 1982 remains valid today:

  "Research implicates noise as one of several factors producing stress-related health effects such as heart disease, high blood pressure and stroke, ulcers and other digestive disorders. The relationship between noise and these effects has not yet been quantified."

➤ **Behavioral Effects**—Behavioral effects are usually measured in terms of interference with human activities. Speech interference and interference with the enjoyment of radio or television are the most often cited examples. Interference with concentration on mental activities and disruption of sleep are two others. Most of the readily identifiable aircraft noise effects fall into this category.

➤ **Subjective Effects**—By their very nature, subjective effects are unique to each individual and, therefore, difficult to quantify. Subjective effects of noise are commonly described in terms of *annoyance* or other similar terms. Because of the great variability in the ways people perceive and react to the unpleasant aspects of noise, prediction of how any one individual will react is nearly impossible. Most research consequently focuses on identifying predictable results among a group or community of people.

The latter two categories are examined more closely in the following discussion.

Effects of Noise on Human Activities

Speech Communication

Scientific research has found that the maximum continuous sound level that will permit relaxed conversation with 100% intelligibility throughout a typical residential living room (talker/listener separation greater than approximately 3.5 feet) is 45 dB (L_{eq} = 45 dB). A 95% intelligibility—considered to be "satisfactory conversation"—can be obtained with a steady sound level of up to 64 dB. When the noise level approaches 80 dB, intelligibility drops to near zero even when a loud voice is used (EPA–1974). Interference with communication may result from masking of the speaker's words or by causing the speaker to pause.

Figure 7A illustrates the relationships between speech intelligibility, sound level, and distance.

Outdoors, because of the absence of reflecting walls to provide the reverberation found indoors, the sound level of speech as it reaches the ear decreases comparatively more rapidly with increasing distance between the talker and listener. In a steady background noise, there comes a point—as the talker and listener increase their separation where speech can no longer be understood because it is masked by the noise.

Almost all fluctuating sound levels found in the everyday environment will, if averaged over a long time period, have less impact on speech intelligibility than a steady sound which has the same Equivalent Sound Level (L_{eq}). This occurs because most of the time the background noise level is less than the Equivalent Sound Level (because of the logarithmic base of sound intensity measurement, a loud sound need have only a relatively short duration to raise the L_{eq} substantially). In circumstances where assessment of speech interference is particularly important, measurement of the amount of time during which noise levels exceed a level for acceptable communication can be informative.

Effects on Learning

Closely related to speech interference are the effects of noise on learning and, more broadly, on cognitive tasks. Recent studies have shown a strong relationship between noise and children's reading ability (FICAN–2000). Children's attention spans also appear to be adversely affected by noise. Adults are affected as well. Some studies indicate that, in a noisy environment, adults have increased difficulty accomplishing complex tasks.

The current status and future needs for research into the effects of aircraft noise on classroom learning was a topic addressed by FICAN in 2000.

One of the issues associated with assessment of these effects is which noise metric correlates most closely with the impacts. For example, DNL, with its nighttime weighting, may not be the best measure of noise impacts on schools. Also, DNL and L_{eq} were developed primarily to address annoyance issues, not effects on learning or health-related matters. Future research into this issue also may help in assessment of the manner in which the effects of loud, intermittent noise events such as aircraft overflights differ from lower volume, but relatively constant, noise sources such as highways.

The FAA has established L_{eq} 45 dB for noise resulting from aircraft operations during normal school hours as the design objective for school sound insulation projects (FAA Order 5100.38A, Section 712.c).

Sleep Disturbance

The extent to which environmental noise disturbs human sleep patterns varies greatly from individual to individual as well as from one time to another for any particular individual. Whether an individual is aroused by a noise depends upon the individual's sleep state and sleep habits, the loudness or suddenness of the noise, the information value of the noise (a child crying, for example), and other factors. Also, most people adapt over time to increased levels of noise during sleep.

When the noise source emanates from outdoors—as is the case with aircraft noise—additional factors affect the loudness of the noise as heard indoors. The noise level reduction provided by the type of construction is one of these determinants. A greater variable, though, is whether windows are open or closed.

Early studies of the effects of noise on sleep disturbance produced varying results. A major factor in these differences, though, is whether the study evaluated people sleeping in a laboratory or in their own homes. Generally, laboratory studies have shown considerably more sleep disturbance than is evident in field studies. More recent studies, all conducted in the field, have produced relatively consistent results. These studies have included:

- A 1990 British study;
- A 1992 U.S. Air Force study of residents near Castle Air Force Base and Los Angeles International Airport; and
- A 1995 study comparing the effects of the closure of Stapleton International Airport with the opening of Denver International Airport.

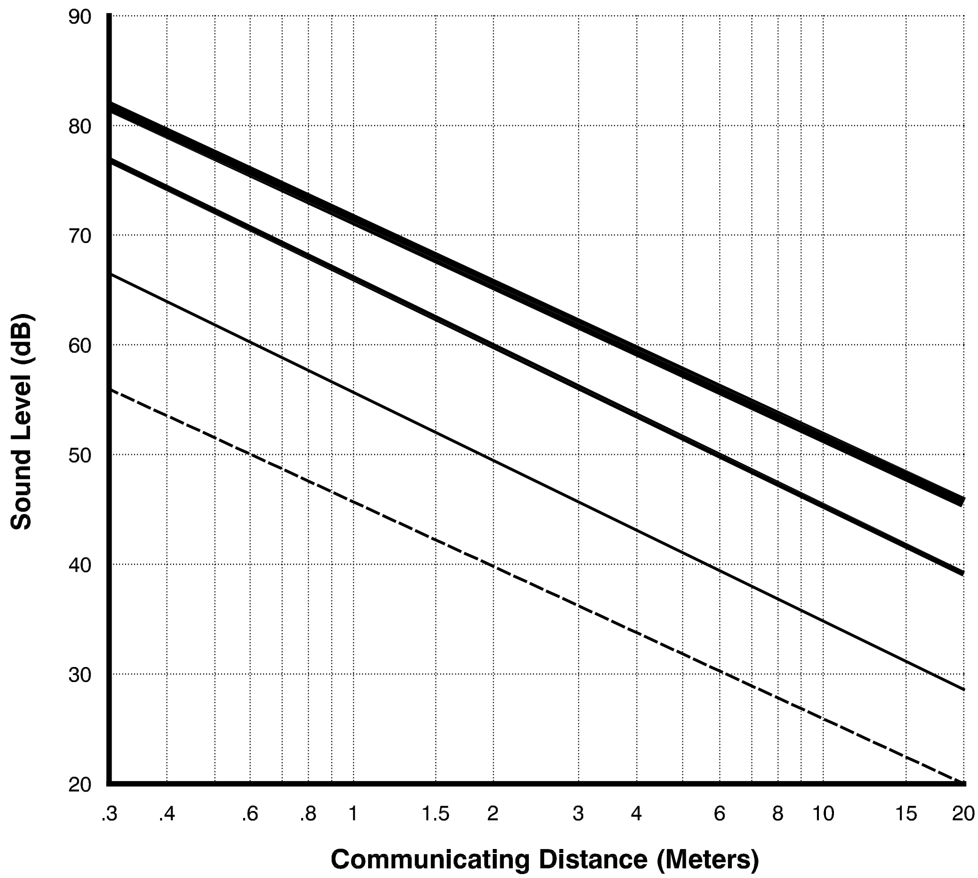
In 1997, the Federal Interagency Committee on Aviation Noise (FICAN) sought to put the subject to rest with publication of a recommended new dose-response curve predicting awakening. This curve (Figure 7B) was calculated using data from the above three studies, among others. The 1997 FICAN curve represents the upper limit of the observed field data and should be interpreted as predicting the maximum percent of the exposed population expected to be behaviorally awakened.

FICAN found a much lower likelihood of awakenings from noise than had been indicated in earlier studies, including the 1992 FICON report. For example, at an indoor sound exposure of SEL 80 dB, the FICAN curve predicts 10% awakenings. By comparison, FICON predicted over 30%. FICAN, however, notes two particular caveats to the prediction curve: (1) it applies only to long-term residents; and (2) it cannot be generalized to apply to children in that only adults were included in the studies.

Subjective Reactions to Noise

Factors Influencing Individuals' Annoyance at Noise

Numerous studies have been conducted which attempt to identify the types of factors which contribute to an individual's annoyance at noise. Annoyance as assessed in most of these studies is not limited to reactions separate



Maximum distance outdoors over which conversation is considered to be satisfactory; intelligible in steady noise.

- Raised voice satisfactory conversation (sentence intelligibility 95%)
- Normal voice satisfactory conversation (sentence intelligibility 95%)
- Relaxed conversation (sentence intelligibility 99%)
- Relaxed conversation (sentence intelligibility 100%)

Source: U.S. Environmental Protection Agency (1974)

FIGURE 7A

Relationship Between Noise Levels and Conversation

Annoyance Factors

- Demographic characteristics of the individual (age, sex, economic status, etc.).
- Residential dwelling characteristics (single versus multi-family; owner-occupied versus rental).
- The loudness, tonal qualities, and other inherent unpleasant characteristics of the noise itself.
- How often the noise occurs.
- The duration of the noise.
- The predictability of the noise.
- Experience and expectations regarding noise levels in the community (is the noise likely to get better or worse in the future?).
- Personal sensitivity to noise.
- Beliefs regarding the preventability of the noise.
- Attitudes regarding the importance of the activity associated with the noise.
- Perceptions concerning the extent to which efforts have been made to minimize the noise levels.
- The activity in which the individual is engaged at the time of the noise.
- Beliefs regarding the health effects of noise.
- Feelings of fear or anxiety associated with the noise.

from interference with speech communication, disturbance to sleep, and other such behavioral effects. Rather, annoyance is a complex reaction to many physical and emotional factors, including adverse effects on behavior.

Listed in the adjacent box, in no particular order, are many of the factors which have been demonstrated to influence the extent of an individual's annoyance at noise. As can be seen, some of these factors are objective, measurable influences, but many are highly subjective. The significance of these subjective factors varies widely from individual to individual and, even for a given individual, from one set of circumstances to another.

The last factor in the adjacent list suggests that annoyance is not strictly a noise-derived phenomenon, but one which also involves a safety component. This factor is particularly important with respect to annoyance at aircraft overflights. Although people may not fear the aircraft noise itself, they may be apprehensive of the prospect that an aircraft could crash onto their property and it is the noise that mostly creates their awareness of the aircraft's presence. The altitude of the aircraft and individuals' understanding of how aircraft fly thus are additional factors in the airport-related annoyance equation.

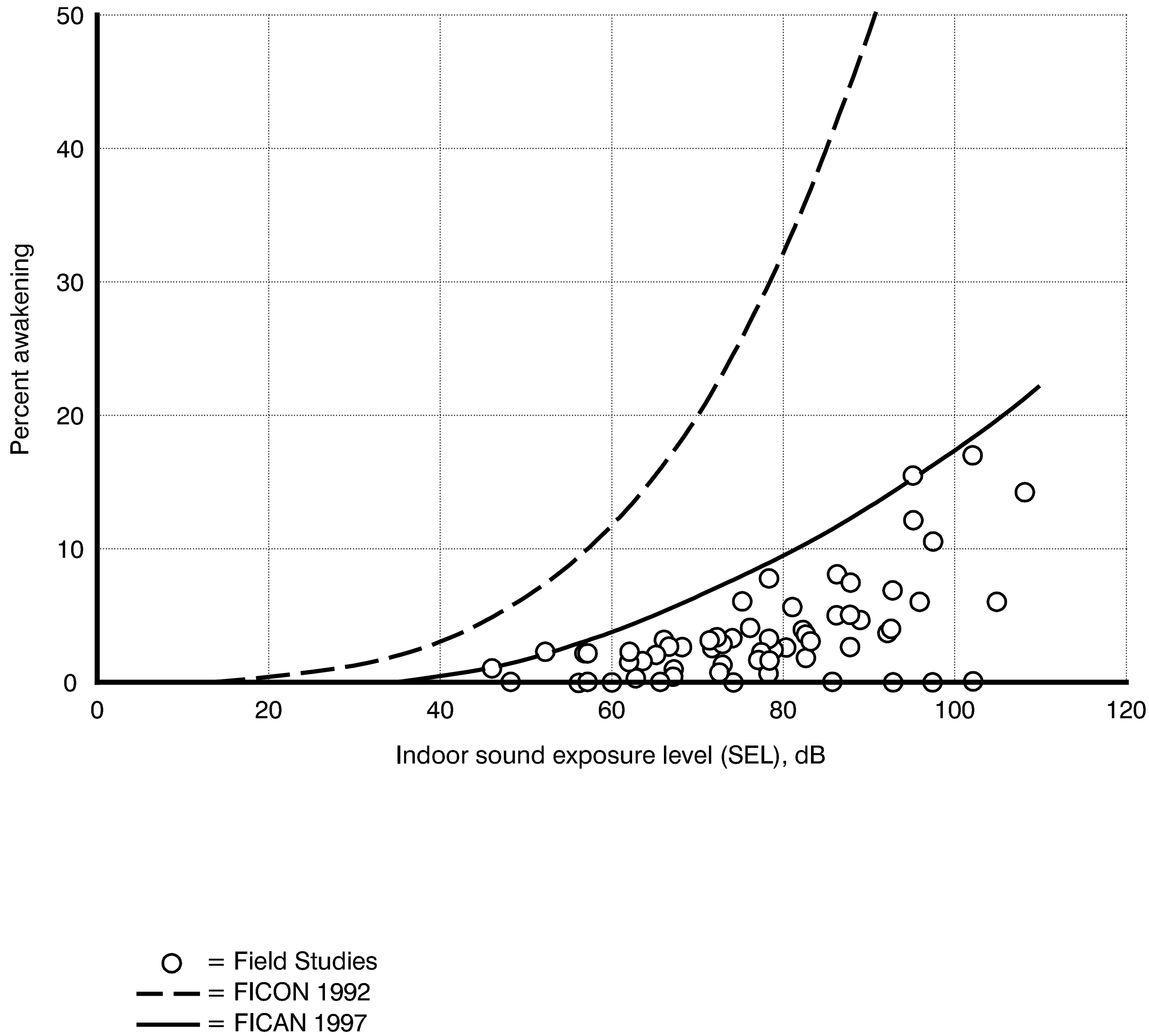
Rates of Annoyance

Even though studies have been able to identify most of the factors affecting an individual's annoyance at noise, predicting how any one individual will react to typical environmental noises has proved virtually impossible. Consequently, most studies seek instead to assess the rate of annoyance within broad segments of the population.

Perhaps the most comprehensive and widely accepted evaluation of the relationship between transportation noise exposure (not exclusively aviation noise) and the extent of annoyance was one originally developed by Schultz (1978) and later updated by the U.S. Air Force (Finegold–1992). This relationship—known as the Schultz curve (Figure 7C)—indicates the percent of people found to be *highly annoyed* (%HA) at various levels of noise exposure measured in terms of the DNL metric. Both of these studies represent compilations of findings from a number of social surveys conducted by other researchers.

A summary of the effects of noise on people, including the reactions of average communities is presented in the FICON report. This summary is reproduced here as Table 7A.

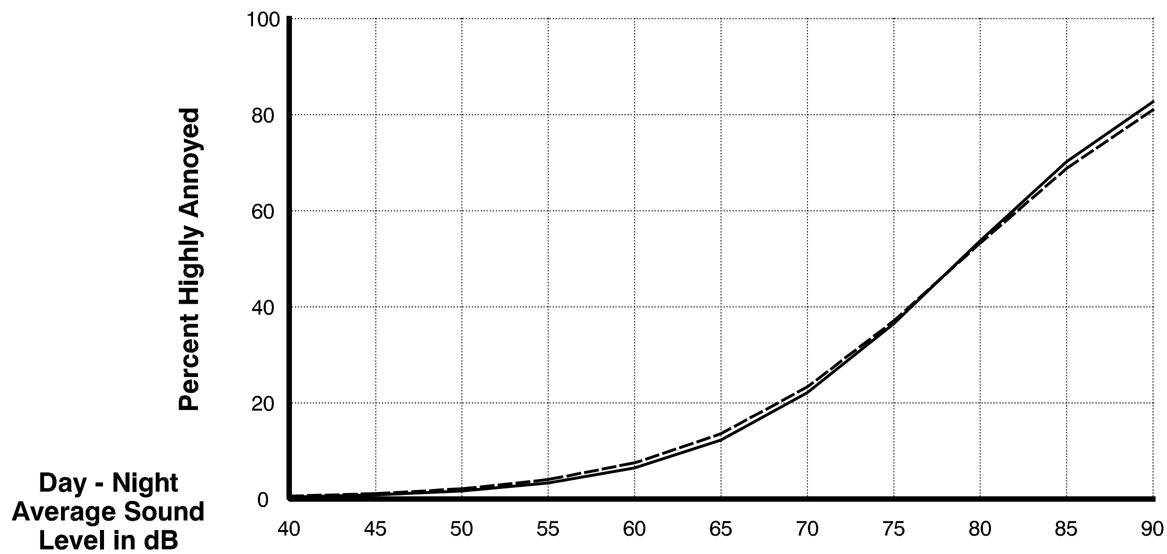
The Schultz curve indicates that approximately 13% of the population is highly annoyed at a DNL of 65 decibels. It also indicates that the percent of people describing themselves as being highly annoyed (%HA) accelerates smoothly between a DNL of 55 dB and a DNL of 70 dB. A DNL of 65 dB is a commonly referenced dividing point between lower and higher rates of people describing themselves as being highly annoyed. The Federal Aviation Administration selected the DNL of 65 dB as the dividing point between normally *compatible* and normally *incompatible* residential land



Source: Federal Interagency Committee on Airport Noise (1997)

FIGURE 7B

Sleep Disturbance Dose-Response Relationship



Calculated % HA Points

USAF	0.41	0.83	1.66	3.31	6.48	12.29	22.10	36.47	53.74	70.16	82.65
Schultz	0.58	1.11	2.12	4.03	7.52	13.59	23.32	37.05	53.25	68.78	81.00

——— USAF (Finegold et al. 1992) data: 400 points
%HA = 100/(1 + EXP (11.13 - .141 LDN))

– – – – Schultz data: 161 points
%HA = 100/(1 + EXP(10.43 - .132 LDN))

Comparison of logistic fits to original 161 data points of Schultz (1978) and USAF analysis with 400 points (data provided by USAF Armstrong Laboratory)

Source: Federal Interagency Committee on Noise (1992)

FIGURE 7C

Relationship Between Noise Levels and Annoyance

(Schultz Curve)

Day-Night Average Sound Level (Decibels)	Effects[1]			
	Hearing Loss *(Qualitative Description)*	**Annoyance**[2] *(Percentage of Population Highly Annoyed)*[3]	**Average Community Reaction**[4]	**General Community Attitude Toward Area**
≥75	May begin to occur	37%	Very severe	Noise is likely to be the most important of all adverse aspects of the community environment.
70	Will not likely occur	22%	Severe	Noise is one of the most important adverse aspects of the community environment.
65	Will not occur	12%	Significant	Noise is one of the important adverse aspects of the community environment.
60	Will not occur	7%	Moderate to Slight	Noise may be considered an adverse aspect of the community environment.
≤55	Will not occur	3%		Noise considered no more important than various other environmental factors.

[1] All data is drawn from National Academy of Science 1977 report *Guidelines for Preparing Environmental Impact Statements on Noise*, Report of Working Group 69 on Evaluation of Environmental Impact of Noise.

[2] A summary measure of the general adverse reaction of people to living in noisy environments that cause speech interference; sleep disturbance; desire for tranquil environment; and the inability to use the telephone, radio or television satisfactorily.

[3] The percentage of people reporting annoyance to lesser extents are higher in each case. An unknown small percentage of people will report being "highly annoyed" even in the quietest surroundings. One reason is the difficulty all people have in integrating annoyance over a very long time. USAF Update with 400 points (Finegold et al. 1992)

[4] Attitudes or other non-acoustic factors can modify this. Noise at low levels can still be an important problem, particularly when it intrudes into a quiet environment.

NOTE:
Research implicates noise as a factor producing stress-related health effects such as heart disease, high blood pressure and stroke, ulcers and other digestive disorders. The relationships between noise and these effects, however, have not as yet been conclusively demonstrated. (Thompson 1981; Thompson et al. 1989; CHABA 1981; CHABA 1982; Hattis et al. 1980; and U.S. EPA 1981)

Source: Federal Interagency Committee on Noise (1992)

TABLE 7A

Summary of Effects of Noise on People

use (see discussion later in this chapter). The extremes of the curve are also worth noting. At the low end, the data reflect the findings of social surveys that a few people will be highly annoyed regardless of how minimal the noise level is (about 0.6% at a DNL of 40 dB). Oppositely, nearly 20% of the population is apparently not highly annoyed even at a DNL of 90 dB.

Two factors should be recognized with respect to applying the Schultz curve to establishment of airport noise compatibility policies:

➤ **Differences between Sources of Noise**—The Schultz curve is based upon the findings of research on all types of transportation noise. Some studies have suggested that aircraft noise is more annoying than highway noise at the same DNL exposure. Other studies have found similar responses regardless of the source of noise. There are many factors that could not be standardized in the studies analyzed by Schultz. These include weather, design of residential structure, types of thermal or acoustic insulation included in structures, types of windows, etc.

➤ **Significance of Background Noise Levels**—The studies forming the basis of the Schultz curve were primarily conducted in urban or other relatively noisy environments. A variable discussed by Schultz in his assessment of annoyance is the effect of background or ambient noise in a community. Unfortunately, the data available to Schultz did not provide a basis for determining this effect. Background noise levels are one of the factors taken into account in the concept of normalization described later in this chapter.

Complaints

One manner in which annoyance at noise is sometimes exhibited is through complaints. Many airports maintain logs of noise complaints received. In addition to providing an avenue for people to express their concerns, noise complaint phone lines can help in identifying the nature and location of particular airport noise problems.

Complaints, however, cannot necessarily be equated to annoyance rates within a community. Annoyance can exist without resulting in complaints and complaints may occur even without a high rate of annoyance. Moreover, there is not necessarily a correlation between complaints and noise exposure. At many airports, residential areas subjected to the highest noise levels produce relatively few complaints perhaps because of the predictability of the events. More common is for the majority of complaints to originate from locations outside the defined noise contours. Most complaints tend to be associated with:

- Exceptionally loud, large, or low-flying aircraft which are not normal for the airport;
- Changes in flight patterns which cause increased noise impacts; or
- A small number of people who frequently complain about airport activities.

Other Variables in Airport-Related Noise Annoyance

Several other inter-related variables appear to influence the extent of airport-related annoyance within a community. For some of these, relatively little research has been conducted. The apparent significance is thus more qualitative than quantified.

➤ **Differences among Airport Types**—Virtually all research on airport noise has been conducted at major airline airports, most of which are located in urban areas. The aircraft activity at these airports generates relatively predictable, frequent, loud noise events. In contrast, most general aviation airports have relatively few loud noise events and the total number of aircraft operations may vary substantially from day to day. Also, many general aviation airports are located in relatively quiet, suburban or rural settings where aircraft noise may be perceived as more intrusive than in noisier communities.

➤ **Significance of Overflight Frequency versus Noise Event Loudness**—Cumulative noise exposure metrics reflect a combination of both the frequency with which overflights occur and the loudness of those events. Any given noise exposure level can be the result of either a small number of noisy overflights or a high incidence of just moderately noisy events. A basic assumption in use of cumulative noise contours for compatibility planning is that community reactions will be the same under each of these circumstances.

➤ **Time of Day Weighting**—Some evidence suggests that, because people are more likely to be home during the evening (7:00 p.m. to 10:00 p.m.) and nighttime (10:00 p.m. to 7:00 a.m.) than in the day, the same noise exposure produces more annoyance during those hours. This consideration is reflected in the CNEL metric by inclusion of a penalty factor on evening and nighttime aircraft operations.

Communication of Airport Noise Data

In seeking to measure or predict the effects of noise on people and to establish appropriate noise level criteria, most noise research and airport-specific noise studies have relied upon cumulative noise exposure metrics as the basis for describing noise levels. Cumulative noise exposure metrics are usually very well-suited to this task. Sometimes, though, the need is not to *assess* how noise affects people, but to *explain* noise information to people. This need often arises in the preparation of environmental impact analyses of airport improvement projects.

For noise communication purposes, metrics such as CNEL and DNL may not provide all of the information desired. The general public often finds it difficult, if not impossible, to understand the relationship between cumulative noise exposure contours and the airport noise they experience or will experience. Rather, people tend to focus on where aircraft are flying, how often they fly, and the extent to which the noise is or will be intrusive or annoying. To

A point to emphasize here is that use of supplemental noise metrics as a means of improving airport noise data communication does not diminish the importance and viability of cumulative noise exposure metrics as analytical and compatibility planning tools.

better communicate airport noise data in everyday terminology to which the public can more readily relate, supplemental noise metrics may be helpful. A variety of such metrics have been used in the U.S. and abroad. Few, though, have attained widespread application or general consensus as to their merit.

NOISE CONTOURS FOR COMPATIBILITY PLANNING

Although supplemental metrics may be useful for certain purposes, cumulative noise exposure metrics and the noise contours associated with these metrics continue to represent the best available tools for the purposes of airport land use compatibility planning. The previous chapter described some of the basic input data required for preparation of current airport noise contours. The focus in the following discussion is on issues to be considered in projecting future noise impacts and in selecting contours for land use compatibility planning purposes.

Noise Analysis Time Frame

See the discussion in Chapter 2 regarding preparation or updating of aviation activity forecasts for airport land use compatibility planning purposes.

State statutes specify that airport land use compatibility plans must be based upon an airport development plan "that reflects the anticipated growth of the airport during at least the next 20 years." Forecasts having the required 20-year time horizon are normally included in airport master plans. The FAA, the Division of Aeronautics, and some regional planning agencies also prepare individual airport forecasts, some extending to 20 years.

DEPT. OF TRANSPORTATION GUIDANCE
The "at least" phrase in the statutory guidelines deserves emphasis. The 20-year time frame should be considered a *minimum* for compatibility plans. Noise impacts (as well as other compatibility concerns) should be viewed from the longest practical time perspective.

For the purposes of compatibility planning, however, 20 years may be shortsighted. For most airports, a lifespan of more than 20 years can reasonably be presumed. Moreover, the need to avoid incompatible land use development will exist for as long as an airport exists. Once development occurs near an airport, it is virtually impossible—or at least very costly and time consuming—to change the land uses to ones which would be more compatible with airport activities.

In conducting noise analyses for compatibility plans, the long-range time frame is almost always of greatest significance. Barring vast improvements in aircraft noise reduction technology, the growth in aircraft operations expected at most airports will result in larger noise contours. A possible exception to this trend is that, at some airports, planned changes in runway configuration or approach procedures could result in reduction of noise impacts in some portions of the airport environs. In these instances, a combination of current and future noise contours may be the appropriate basis for compatibility planning.

Past improvements in aircraft noise reduction technology—or, more to the point, the elimination of older, noisier aircraft from the fleet—have caused noise contours at some airports to shrink. One result of shrinking contour sizes during the late 1990s was pressure to allow residential and other noise-sensitive development closer to airports. Allowing such development might be reasonable in situations where no potential exists for the contours to expand back to their former size (for example, where policies to limit contour sizes have been adopted). However, whether future technology will again enable significant reduction in noise impacts is uncertain. Thus, looking to the long-range future, the scenario which has the greatest land use planning implications for most airports is that anticipated future growth in airport activity will result in expansion of noise contours.

Other Factors in Noise Contour Selection

In addition to time frame and forecasting issues, several other factors warrant consideration in selection of noise contours for compatibility planning functions.

Lowest Noise Contour Level

Calculating at least one 5-dB CNEL contour interval below the threshold level can provide valuable supplemental information for land use planning. Aircraft noise does not become suddenly unnoticeable just beyond the CNEL contour that delineates the threshold for determining compatible versus incompatible land uses. The additional contour(s) can show where noise levels are below the level at which residential and certain other noise-sensitive land uses may need to be prohibited or substantially restricted, yet still may be noticeable and may warrant some form of land use compatibility measure. When applying this concept, it is important to recognize that CNEL contours become less precise the further they are from the airport.

Supplemental Forecast Scenarios

At some airports, the distribution of activity throughout the year or among aircraft types is such that an annual average forecast is insufficient for full assessment of noise impacts.

For instance, an airport may have distinct seasonal or even daily variations in its activity. Such circumstances may warrant examination of noise contours reflecting these shorter periods in addition to the annual average impacts. These variations are particularly interesting when activity by the noisiest aircraft are concentrated into one part of the year. The predominantly summertime operations of fire attack aircraft is one common example.

Another situation in which supplemental forecast scenarios may be needed is when there is substantial uncertainty regarding a major component of the airport activity. Examples include: possible changes in airline aircraft fleet mix and/or volume of operations; potential addition or elimination of particularly noisy based aircraft; and/or uncertainties in activity levels by aircraft which follow unique flight tracks (such as helicopters or agricultural applicator aircraft).

As long as the assumptions used in these supplemental forecast scenarios are consistent with the defined role of the airport, it is within reason for ALUCs to consider them.

Special Noise Sources

As noted in Chapter 6, most noise contour calculations only take into account the noise from approaches/landings, takeoffs/departures, and closed traffic pattern (touch-and-go) activity of typical airplanes. In some circumstances, Including helicopter operations in noise contour calculations generally will not have much effect on the size or shape of noise contours unless the traffic volumes are quite high. In these instances, the location of common helicopter flight tracks and the single-event noise levels of helicopter overflights may be appropriate to consider in compatibility planning.

other sources of aircraft noise may also need to be considered. These include:

- **Helicopters**—Because of helicopters distinct noise characteristics and the fact that they usually follow different flight tracks than used by airplanes, their noise can be particularly noticeable. Inclusion of helicopter noise in computation of airport noise contours is desirable, especially at airports having moderate or high levels of helicopter activity.
- **Agricultural Aircraft**—Another group of aircraft having unique noise characteristics is agricultural "crop duster" aircraft. From a noise contour standpoint, one characteristic is that, unless numerous flight tracks are modeled, the calculated contours tend to maintain a constant width along the flight tracks and never reach a closure point.
- **Ground Operations**—For most airports, the various sources of aircraft ground operations described in Chapter 6 are not a significant source of noise. Noise from engine run-ups can be included in INM calculations, however. At airports where this activity is a noise factor, the capability of INM to include it in the noise contours should be utilized. If included, some reference to the fact should be noted in the description of the contours.

Sources of Noise Contours

The preceding discussion focuses on issues involved in development of noise contours suitable for compatibility planning. However, it may not be necessary for ALUCs to develop new contours. Noise contours are available from a variety of sources. Some of these are potentially useful for airport land use compatibility planning purposes, others are of limited value.

Potential sources and applicability of noise contours can be summarized as follows:

- **Airport Master Plans**—As indicated above, an adopted airport master plan is one of the preferred sources for airport activity forecasts and noise contours. Even when the forecasts and contours in a master plan no longer extend at least 20 years into the future, information contained about the intended role and future physical characteristics of the airport is needed for compatibility planning.
- **Noise Elements of Community General Plans**—The status of noise contours depicted in general plans is similar to that of noise contours from airport master plans in that they represent adopted local policy. As for utility in compatibility planning, again the principal concern is currentness. More often than not, noise contours included in general plans are copies of ones from the most recent airport master plan.
- **Environmental Documents**—State environmental impact reports and/or federal environmental assessments and environmental impact statements conducted for major airport improvements normally will contain newly prepared noise contours having a 20-year time horizon. Depending upon the timing of the project, these contours may be more recent than ones in an airport master plan.
- **FAR Part 150 Studies**—Most of the airline and busier general aviation airports in the state have conducted FAR Part 150 noise compatibility studies. These studies contain current and five-year projected noise contours. At airports where noise impacts are expected to decrease in the future, the Part 150 noise exposure maps are appropriate for land use compatibility

planning purposes. If the noise exposure is expected to expand beyond the five-year time frame, then noise contours do not provide a sufficiently long time horizon and generally should not be used for policy purposes. Even in this latter case, though, the contours can be useful in illustrating anticipated noise impact trends and the noise model input data can be valuable in preparation of longer range noise contours.

➤ **AICUZ Studies**—Often the only sources of noise contours for military airfields are the Air Installation Compatible Use Zone studies conducted by the Department of Defense. Because aircraft activity levels at most military facilities is highly dependent upon international events, the contours usually represent current conditions and long-range projections are seldom done. Often, though, a "maximum mission" scenario will be analyzed which can be useful for compatibility planning.

ESTABLISHING CUMULATIVE NOISE EXPOSURE CRITERIA

Just as there are no absolute determinants of the noise level at which an individual person will be highly annoyed, there are no absolute scientific measures for establishing which land uses and noise exposures are or are not compatible with each other. The best that can be hoped for is that compatibility criteria will reflect what is *appropriate* for the communities involved. The Schultz curve depiction of the percentages of people highly annoyed by various noise levels is a cornerstone for the task of establishing noise criteria for land use planning purposes. It is important to remember, however, that what may be considered an *acceptable* level of noise to a reasonable person will not satisfy 100% of the public.

The Context of Acceptability

The level of noise acceptable to an individual depends greatly upon the context of the noise and the perspective of the listener—noise to one person may be music to another. Similarly, context is important in determining the level of noise acceptable to a community. The level selected depends upon whether the function of the standards is control and abatement of noise sources or making land uses compatible with those sources.

Methods of Limiting Airport Noise Impacts

Methods of limiting airport noise impacts can be divided into four basic groups. All four categories have significant roles to play if the goal of quieter communities is to be attained. Importantly, the authority for implementation of each method differs.

➤ **Source Noise Reduction**—From the perspective of most communities, the ideal method of limiting airport noise impacts is to reduce aircraft noise at its source. However, local entities—including airports, local land use jurisdictions, and ALUCs—have no control over this technique. Responsibility for source noise reduction actions rests with the federal government (which sets standards and conducts research), aircraft manufacturers (which design and build new technology aircraft), and aircraft owners (which place the new aircraft in their fleets). A basic difficulty with implementation of this process is that it takes time between when new technologies are created and when they are put into use.

- **Operational Limitations**—Operational methods to reduce noise include a variety of measures affecting how, where, and when aircraft are flown. The principal authority over these actions rests with the federal government and the pilots of aircraft. Airport proprietors have some regulatory powers (setting restrictions on aircraft types, hours of operation, or flight track locations, for example) to the extent that the actions do not adversely affect safety and are implemented in a manner which is reasonable, nonarbitrary, and nondiscriminatory. Airport proprietors also can affect where aircraft fly by modifying the configuration of airport runways. Other than when they are also the airport proprietor, local governments have no authority over aircraft operations. Airport land use commissions are explicitly denied this power.

Among the four categories of noise impact reduction methods, preventative measures are the only category in which ALUCs have any authority.

- **Preventative Measures**—Falling into this category are the wide variety of land use planning measures designed to avoid encroachment of incompatible development into airport environs. These measures include general plans, specific plans, and zoning ordinances adopted by local governments. Compatibility plans adopted by ALUCs are another example.

Avigation easements, although they provide a legal means of complying with state Airport Noise Regulations, are not truly remedial actions in that they do not physically change the noise environment.

- **Remedial Actions**—This group of actions are ones designed to mitigate current and future noise impacts on established land uses around airports through modification of the land uses. The objective is to change existing incompatible land uses into ones which are compatible or at least more acceptable. Property redevelopment and reuse are examples of remedial actions which can be fostered by local governments and taken by property owners. Airport proprietors can effect remedial action through programs such as property acquisition and soundproofing of existing structures.

Functions of Noise Impact Criteria

Not only does the authority to implement each of the preceding noise impact reduction methods differ, the standards which the methods seek to achieve may vary as well. Indeed, in the case of source noise reduction, even the metric used to measure compliance differs. It is a single-event metric, whereas the other methods are primarily evaluated in terms of cumulative noise level metrics. Particularly important with respect to the methods over which ALUCs and local land use jurisdictions have authority are differences in objectives for preventative measures versus remedial actions. The noise levels considered *appropriate*—as opposed to *optimum* or *ideal*—under each of these two contexts may not be the same.

Yet another matter is the issue of noise increases resulting from airport development or operational changes. This issue is explored in the final section of this chapter.

In each case, setting appropriate noise level criteria for a community implies that an element of feasibility or cost-effectiveness is being taken into account. For example, within the limits of powers available to local governments, it is usually more feasible to avoid creation of new incompatible land uses than it is to reduce existing noise impacts through land use changes. Moreover, while the benefits or effectiveness may be the same in each case, the cost of eliminating or mitigating existing land use incompatibilities is usually far greater than avoiding it in the first place. *Thus, noise level criteria might justifiably be set lower for new land use development than for triggering action to mitigate existing impacts.*

Even for new development, competing community needs can influence the level deemed to constitute acceptable noise. As examined in Chapter 3, various practical considerations can shift the line of demarcation between acceptable and unacceptable noise exposure. ALUCs need to reflect upon such factors when establishing noise compatibility criteria. In so doing, however, commissions should also remember that their primary responsibility is toward promoting compatibility between airports and proposed land use development in the airport vicinity. Local elected officials can weigh the importance of other factors if they so choose (in so doing, though, they must understand that any action to overrule a decision of an ALUC must adhere to the procedural requirements set forth in state law).

Variables Affecting Cumulative Noise Level Criteria

As noted in the review at the outset of this chapter, most federal and state of California regulations and policies set DNL/CNEL 65 dB as the basic limit of acceptable noise exposure for residential and other noise-sensitive land uses. Often overlooked, though, is that this standard has been set with respect to relatively noisy urban areas. For quieter settings and many—if not most—airports in California, CNEL 65 dB is too high of a noise level to be appropriate as a standard for land use compatibility planning. This view is particularly evident with respect to evaluation of proposed new land use development. Even FAA policy has evolved to where the agency now will “respect and support” local establishment of a lower threshold of noise exposure acceptability. On the other hand, special situations continue to exist in which noise exposures above CNEL 65 dB may be regarded as appropriate.

As discussed elsewhere, DNL is the only metric for which there is a substantial body of research data defining the relationship between noise exposure and people’s reactions (as noted in Chapter 6, the CNEL metric used in California is essentially the same as DNL). Furthermore, cumulative noise exposure metrics remain the only metrics suited to establishment of policies defining the noise levels considered acceptable or compatible with various land uses.

Clearly, the level of noise deemed acceptable in one community is not necessarily the same in another. The issue which therefore needs to be examined is what factors influence setting of appropriate noise level criteria.

The Concept of Normalization

A long-standing method of adjusting noise levels in a community is the concept of “normalization.” The normalization concept has its origin in research done for the U. S. Air Force in the 1950s. The purpose of the research was to establish a method for adjusting aircraft noise levels used for determining and predicting expected community reactions. The adjustments take into account local conditions as described below. National recognition and support of normalization appeared in the U. S. Environmental Protection Agency’s (EPA) *Community Noise* (1971) and “Levels” (1974) documents. The California Department of Transportation also used the normalization process in its development of Noise Standards for California airports, and the California Office of Planning and Research continues to include the normalization procedure in its *Guidelines for Development of General Plans*.

The normalization procedure was originally designed to adjust or "normalize" actual measured noise levels so that the effects of different noises on different communities could be compared more reliably. Over the years, planners have also found normalization to be a valuable tool for establishing appropriate noise level limits for new noise-sensitive development in the vicinity of an airport. This latter application of normalization is particularly well-suited to airport land use planning.

The normalization procedure takes into account four categories of adjustment factors associated with the noise source and the characteristics of the affected community:

- Seasonal characteristics of the noise;
- The background noise level in the community, absent distinct noise events;
- The community's previous exposure to, and attitudes toward the noise; and
- Whether the noise includes pure tones or impulse characteristics.

Figure 7D shows the common background noise levels, measured in terms of Community Noise Equivalent Level, assumed to occur in the various community settings identified in Table 7B.

Table 7B lists the complete set of normalization factors and recommended adjustments to measured noise levels. To use this table for the purpose of setting a land use compatibility noise-level criterion, the values must first be reversed (positive for negative and vice versa). The results can then be applied to adjust a baseline noise-level criterion. In California, a commonly used baseline criterion is a CNEL of 65 dB. As discussed earlier, this criterion is indicated in the Noise Standards for California airports, in FAA guidelines, and elsewhere. It is the cumulative noise level defined as being acceptable to a reasonable person (a person whose sensitivity to aircraft noise is near the middle of public response) residing in an urban setting in the vicinity of an airport.

The two examples on the top of the following page illustrate the use of normalization in airport land use compatibility planning.

DEPT. OF TRANSPORTATION
GUIDANCE
ALUCs are encouraged to consider the normalization factors listed in Table 7B when setting noise level limits for new noise-sensitive development in the vicinity of an airport.

ALUCs are encouraged to consider the normalization factors listed in Table 7B when setting noise level limits for new noise-sensitive development in the vicinity of an airport. However, caution should be exercised in the event that the normalization procedure indicates a planning criterion greater than a CNEL of 65 dB. With few exceptions, new noise-sensitive land uses should not be allowed where current or projected airport related noise exceeds a CNEL of 65 dB. To do so would be inconsistent with the overall goals and objectives of the Noise Standards for California airports.

It should also be noted that normalization is not applicable to implementation of the Noise Standards for California airports. The Noise Standards are formal regulations that have their own requirements separate from land use planning guidelines.

Examples of Using Normalization in Airport Land Use Compatibility Planning

Example 1: An urban residential community near a major air carrier airport.

Factor	*Characteristics Present in Community*	*Correction*
Seasonal Character of Noise:	Year-round operation	0
Community Setting:	Typical urban residential background noise levels	0
Previous Community Exposure to Noise:	Some exposure, but no control of noise	0
Noise Qualities:	No pure tones or impulse characteristics	0

Under these conditions, no corrections would be made to the basic CNEL 65 dB criterion as the design guideline.

Example 2: A small airport in a quiet location.

Factor	*Characteristics Present in Community*	*Correction*
Seasonal Character of Noise:	Year-round operation	0
Community Setting:	Quiet suburban area	-10 dB
Previous Community Exposure to Noise:	Some exposure, but no control of noise	0
Noise Qualities:	No pure tones or impulse characteristics	0

Under these assumptions, a total correction of minus 10 dB would be applied to the basic criterion of CNEL 65 dB. A community fitting these conditions therefore may find that a criterion of CNEL 55 dB should be set as the maximum acceptable noise exposure for new residential and other noise-sensitive land use development.

At the present time, normalization is the best method available for quantitatively adjusting noise levels to account for local conditions in an effort to establish appropriate noise limits for noise-sensitive land uses near airports. Its applicability is perhaps greatest in relatively quiet suburban or rural communities. The normalization procedure has also proven to be capable of predicting controversial airport noise situations such as around the new Denver International Airport, the reorganization of airspace along the eastern U. S. coast (Expanded East Coast Plan), and sightseeing flights over the Grand Canyon.

Varying Noise Sensitivity of Different Land Uses

Noise compatibility standards, such as those summarized at the beginning of this chapter, typically place primary emphasis on residential areas. Residential development is not only one of the most noise-sensitive land uses, it usually covers the greatest proportion of urban land. Several factors contribute to this sensitivity:

- Normal residential construction usually provides less sound attenuation than typical commercial construction and windows are more likely to be open;
- Outdoor activity is a significant aspect of residential land use; and
- People are particularly sensitive to noise at night when they are trying to sleep.

The three Community Noise Exposure Levels commonly used as the limit for acceptable residential noise exposure are: CNEL 65 dB, 60 dB, or 55 dB. The choices and the rationale for each are listed in Table 7C.

DEPT. OF TRANSPORTATION GUIDANCE
For the purposes of airport land use compatibility planning, the Department's advice is that CNEL 65 dB is not an appropriate criterion for new noise-sensitive development around most airports. At a minimum, communities should assess the suitability and feasibility of setting a lower standard for new residential and other noise-sensitive development.

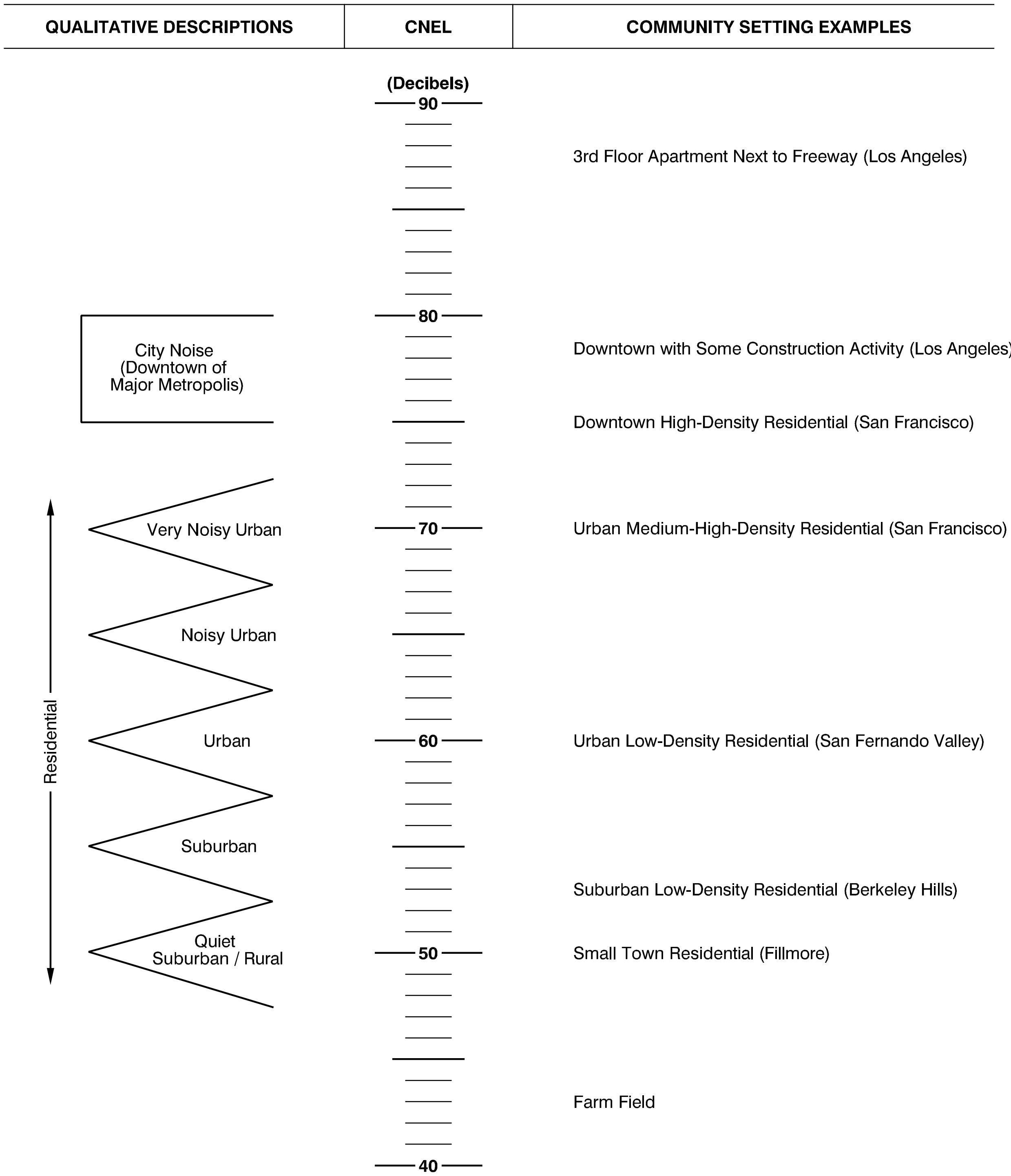
Type of Correction	Description	Amount of Correction to be Added to Measured CNEL in dB *
Seasonal Correction	Summer (or year-round operation).	0
	Winter only (or windows always closed).	– 5
Correction for Outdoor Noise Level Measured in Absence of Intruding Noise	Quiet suburban or rural community (remote from large cities and from industrial activity and trucking).	+ 10
	Normal suburban community (not located near industrial activity).	+ 5
	Urban residential community (not immediately adjacent to heavily-traveled roads and industrial areas).	0
	Noisy urban residential community (near relatively busy roads or industrial areas).	– 5
	Very noisy urban residential community.	– 10
Correction for Previous Exposure & Community Attitudes	No prior experience with the intruding noise.	+ 5
	Community has had some previous exposure to intruding noise but little effort is being made to control the noise. This correction may also be applied in a situation where the community has not been exposed to the noise previously, but the people are aware that bona fide efforts are being made to control the noise.	0
	Community has had considerable previous exposure to the intruding noise and the noise maker's relations with the community are good.	– 5
	Community aware that operation causing noise is very necessary and it will not continue indefinitely. This correction can be applied for an operation of limited duration and under emergency circumstances.	– 10
Pure Tone or Impulse	No pure tone or impulsive character.	0
	Pure tone or impulsive character present.	+ 5

* *Notes:*
- Source document uses the equivalent DNL metric.
- See text for guidance on application of these factors to setting maximum noise level criteria for new land use development near airports.

Source: U.S. Environmental Protection Agency (1974)

TABLE 7B

Adjustment Factors for Obtaining Normalized CNEL



Source: Based upon diagram in Office of Planning and Research (1998)

FIGURE 7D

Typical Noise Levels in Various Communities

Data on acceptable noise exposure for other land uses is not as extensive as for residential uses. Some guidelines exist in the various regulations and documents cited earlier in this chapter. In general, once a criterion has been set for residential uses, the criteria for other land uses can be established by considering the comparative extent to which human activities associated with that land use would be disrupted by noise, as well as the degree of structural sound attenuation which typically is provided.

Characteristics of Cumulative Noise Exposure Metrics

Because of these characteristics, supplemental noise metrics can be helpful as means of adding to public understanding of the complexities of airport noise. For example, as discussed later in this chapter, single-event noise exposure metrics can provide relevant information for some purposes.

As noted earlier in this chapter, various studies—the Schultz curve in particular—have demonstrated a strong correlation between cumulative noise exposure metrics such as CNEL and public annoyance. This correlation, together with the lack of comparable data for any alternatives, makes these metrics essential in defining noise-related land use compatibility policies. To make appropriate use of cumulative noise exposure metrics, though, an understanding of some of their particular characteristics is important.

Logarithmic Scale

The logarithmic scale is used to provide meaningful numbers (0 to 140) in describing sound pressures for which the audible range varies enormously (a ratio of over 1,000,000:1).

A fundamental characteristic of cumulative noise exposure metrics is that they measure noise exposure in decibels which are in turn based on a logarithmic scale. These metrics are not widely understood by the general public. Consequently, some explanation of the manner in which individual aircraft noise levels and frequency of operations contribute to the contours is useful.

- **Effect of Occasional Loud Events**—Because of the logarithmic scale, a relatively few operations by aircraft which generate noise levels well above the average for an airport can greatly influence the size of the noise contours. This is particularly true if these operations occur at night or at airports with low volumes of activity.

Figure 7E depicts the relationships between the number of noise events, their loudness (in SENEL), and the resulting CNEL.

- **Effect of Frequency of Operations**—If the distribution of operations by aircraft type, time of day, and so on is held constant, a doubling of the number of operations will increase the CNEL values by approximately 3 dB. The seemingly small size of this change is a result of the logarithmic scale upon which the decibel unit is measured.

Relationship to Peak Noise Levels

Although the logarithmic scale gives added weight to the loudest noise events, the cumulative basis of CNEL metric does not directly depict information regarding peak noise levels. Specifically:

- **Sound Level Averaging**—Cumulative noise exposure metrics represent a logarithmic average of the penalty-weighted hourly noise levels attributable to individual aircraft noise events. The results are equivalent to a constant noise level of the same magnitude, but with penalties added for evening and nighttime noise. Noise measurements on this type of scale correlate well with overall human responses and acceptance. Nevertheless, even when the cumulative noise exposure level is judged accept-

	CNEL = 65 dB	CNEL = 60 dB	CNEL = 55 dB
Criteria	▪ Set by the FAA and other federal agencies as level above which residential land uses may be incompatible if not acoustically treated. ▪ Established by California state regulations as the maximum normally acceptable for residential and certain other land uses at county-designated noise-problem airports. ▪ Schultz curve predicts that about 13% of the population will be highly annoyed at this noise exposure.	▪ The contour within which California Building Code (Section 1208A) requires an acoustical analysis of proposed residential structures, other than detached single-family dwellings. ▪ Suggested by the California Office of Planning and Research *General Plan Guidelines* as the maximum "normally acceptable" noise exposure for residential areas. ▪ Individual noise events will occasionally cause significant interference with residential land use activities, particularly outdoor activities, in quiet suburban/rural communities. ▪ Schultz curve indicates about 7% of population highly annoyed.	▪ Identified by the U.S. Environmental Protection Agency as the level below which "undue interference with activity and annoyance" will not occur. ▪ Individual noise events will seldom significantly interfere with residential land use activities (e.g., interference with speech). ▪ Schultz curve shows about 4% of population highly annoyed at this noise level. ▪ In urban areas, aircraft contribution to this noise level may be less than that of other noise sources.
Suggested Applicability	▪ Generally not appropriate for most new development. ▪ May be acceptable in noisy urban locations and/or in hot climates where most buildings are air conditioned.	▪ Suitable for new development around most airports. ▪ Particularly appropriate in mild climates where windows are often open.	▪ Suitable for airports in quiet, rural locations.

Note: When setting criteria for a specific airport, other characteristics of the airport and its environs also need to be considered. See Table 7B for normalization factors.

TABLE 7C

Noise Compatibility Criteria Alternatives

New Residential Land Uses

able, the peak noise levels of some individual events may be considered intrusive for several seconds.

DEPT. OF TRANSPORTATION GUIDANCE
Calculation of CNEL contours for time periods other than an annual average day deserves ALUC consideration at airports which have notable seasonal variations in activity.

- **Seasonal Variations**—CNEL contours are usually calculated in terms of an average day of the year. Occasionally, shorter time periods are evaluated. Shorter time frames are primarily assessed for airports which have substantial variations in operating characteristics (total volume of operations, type of aircraft, or patterns of runway use) from one season to another. Seasonal variations in noise exposure can be particularly significant at airports where the highest activity levels occur in the summer when outdoor residential living and open windows in dwellings are most common.

Differences Between High- and Low-Activity Airports

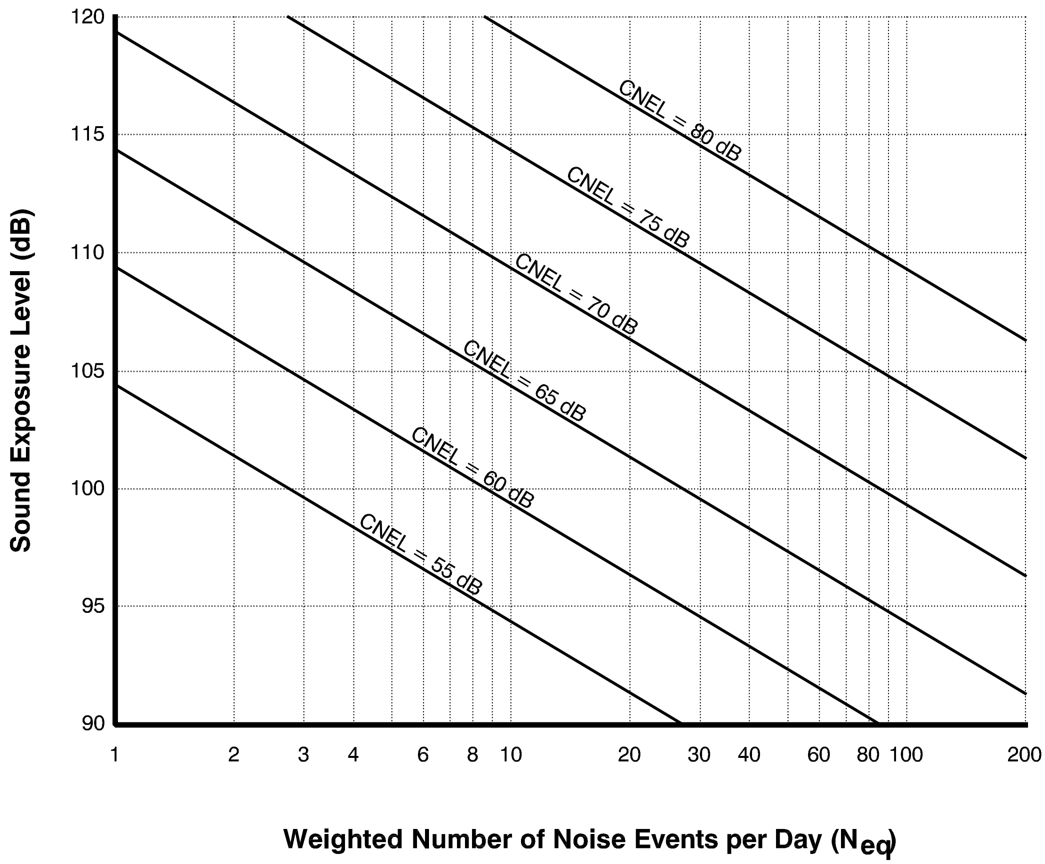
Although cumulative noise exposure metrics have been shown to correlate closely with public annoyance over a wide range of noise exposure levels, there probably are limits beyond which these metrics do not adequately describe potential public reaction. For communities near larger airports with relatively many operations (like air carrier airports), CNEL is well suited to describing anticipated public reaction to aircraft noise. However, at the extreme conditions, where there are either very many relatively quiet events or a small number of very loud events, public reaction is probably more difficult to gauge, and may not be well described.

To illustrate this point, consider two situations in which the CNEL is the same, but the circumstances are quite different. A CNEL of 65 dB due to a single Boeing 727 departure at 2 a.m. would probably have a different effect on people than a CNEL of 65 dB due to one hundred operations of small airplanes during daytime hours. In the first instance, sleep disturbance would be the primary issue; while, in the second case, the issue could well be speech interference. Additionally, the first example would yield one very intrusive event, with quiet prevailing for the rest of the day. The second case would result in a nearly continuously noisy situation, with an aircraft in the air every few minutes. Whether these situations would be equivalent in terms of annoyance is uncertain.

RELEVANCE OF SINGLE-EVENT NOISE LEVELS

When people express their annoyance at airport noise, they often indicate that they are particularly disturbed by the loudest aircraft, ones which use the airport on just an occasional basis. In response to reactions such as this, suggestions have been made that single-event noise level standards should be established. Any thoughts in this regard, however, must draw the distinction between standards applying to aircraft operations and standards directed toward land use compatibility planning. In both respects, there are significant limitations.

Neither ALUCs nor local land use jurisdictions have the authority to regulate the amount of noise individual aircraft generate. Federal laws greatly



$$N_{eq} = Nd + 3 \times Ne + 10 \times Nn$$

Legend: N_{eq} Weighted number of noise events per 24 hours
Nd Number of daytime events (7 a.m. to 7 p.m.)
Ne Number of evening events (7 p.m. to 10 p.m.)
Nn Number of nighttime events (10 p.m. to 7 a.m.)

Note: The above relationship assumes all events are by the same aircraft type (or by aircraft having the same sound exposure level)

FIGURE 7E

Relationship Between CNEL and Sound Exposure Level

constrain even airport proprietors from regulating how, when, and where aircraft operate. However, with respect to land use compatibility planning, nothing in federal or state laws prevents ALUCs from setting standards which rely upon single-event noise level data as a factor in evaluating proposed land use development. There are nonetheless important practical factors which limit the viability of this concept.

Federal Constraints on Single-Event Noise Standards

A fundamental constraint on any local regulation of noise emissions is that the federal government has a preemptive right to set noise level standards for individual aircraft. California, for example, originally included single-event noise emission standards in its Airport Noise Regulations, only to have them later deleted as a result of a successful legal challenge on the basis of federal preemption. As previously indicated, federal law currently prohibits airports from setting single-event noise standards which restrict the operations of federally authorized aircraft over 75,000 pounds takeoff weight unless an extensive cost-benefit analysis is prepared (under FAR Part 161) and subsequently approved by the FAA.

Some airport proprietors have succeeded in adopting single-event noise level standards. Such standards, however, have been limited to specific measurement locations (usually those specified in FAR Part 36 or where noise monitors have been installed). Also, they must have been shown to be nondiscriminatory and to have no deleterious effect on interstate commerce. Furthermore, most have been in place since prior to the 1990 adoption of the current federal legislation (the Airport Noise and Capacity Act) and thus have a grandfathered status. Short of undertaking the FAR Part 161 process, the only other option available to airports for limiting single-event noise levels is through negotiated agreements with airlines and other aircraft operators.

Single-Event Noise Criteria in Compatibility Planning

In each of the above instances, the objective of the single-event noise level policies has been to control noise through restrictions on aircraft operations. The federal constraints on locally established single-event noise standards for *aircraft operations* do not, however, preclude communities and airport land use commissions from adopting *land use* restrictions based upon single-event noise levels. These local entities can adopt land use policies to ensure that single-event noise levels experienced in proposed noise-sensitive land uses will be within acceptable limits. Such policies can help minimize noise intrusions, as well as avoid public reactions that can lead to demands for restrictions on airport operations.

Setting land use restrictions based upon single-event noise levels is not a simple proposition, however. The task is rendered difficult for several reasons: availability of single-event aircraft noise data; criteria selection; and applying the criteria.

Data Availability

A basic difficulty in development of single-event noise level criteria applicable to land use compatibility assessment lies in obtaining suitable aircraft noise data. Three possible sources exist, although each has its limitations.

- **Recorded Data**—Recorded data on actual aircraft overflight noise levels has increasingly become available through noise monitoring systems installed at most major airline airports as well as many busy, urban general aviation facilities. Data for smaller general aviation airports, however, is rarely available unless a special study has been conducted for a particular purpose. Monitoring data is valuable in that it provides an indication of the range of noise levels from various aircraft or even the same type of aircraft.
- **FAR Part 36 Data**—The data resulting from FAR Part 36 is of value only in distinguishing the relative loudness of different types of aircraft. For most airports, especially at general aviation airports, the actual points established by the regulations for measurement of noise levels are too far from the runway to be of much significance in land use planning. Also, the noise levels are measured under very specific conditions which may not represent the manner in which aircraft are actually flown.
- **INM Database**—The only other readily available source of data relating aircraft types to the single-event noise levels at various locations on the ground is the database for the Federal Aviation Administration's Integrated Noise Model (INM). This database provides the typical noise levels for a variety of aircraft types, but does not contain data on the full range of aircraft (airline aircraft are much better represented than general aviation aircraft). Also, unlike monitoring data, the database does not reflect how specific aircraft are operated at a particular airport.

Criterion Selection

Selection of a criterion value is difficult because there has been no widely accepted policy guidance for single-event noise levels. To the extent that there is any guidance regarding acceptable single-event noise levels, the emphasis has been on physiological effects, not on land use planning. For example, the FAA has suggested that the threshold of speech interference is 60 dBA. While this datum is informative, the FAA has not provided guidance indicating what number or duration of events exceeding this threshold should be considered significant. Similarly, FICON and FICAN have provided estimates of the percentage of people expected to be awakened when exposed to specific single-event noise levels inside a home. However, no one has suggested what frequency of awakening is acceptable.

Criterion Application

Assuming that a community has selected a criterion value for maximum single-event noise levels on the basis of some objective analysis, the problem of applying the criterion remains. None of the general single-event noise level data sources cited above may be very useful in evaluating the acceptability of a proposed land use at a specific location near an airport. Noise monitoring at the actual project site could well be necessary. Moreover, such monitoring would need to be conducted over a long enough period to ensure that a full range of aircraft types, flight patterns, and weather conditions are represented.

Conclusions

Perhaps the most salient point which can be made with regard to single-event noise level criteria for land use compatibility planning is that no definitive, widely recognized, single-event noise level guidelines currently exist. The single-event noise research which has been conducted has primarily focused on specific human reactions such as sleep disturbance. The means of applying such research to land use decisions is not yet clear.

DEPT. OF TRANSPORTATION GUIDANCE
ALUC use of single-event noise level data for land use compatibility planning should be narrowly limited.

Until single-event noise level guidelines evolve—if they eventually do—ALUCs have no solid grounds on which to define compatibility criteria relative to specific single-event noise levels. Use of single-event noise level data should be limited to three circumstances:

- In supplemental evaluation of special, highly noise-sensitive, land uses such as schools and outdoor theaters;
- As considerations in the design of acoustical treatments of buildings (if ALUC policies or project reviews go into that level of detail); and
- As one of the factors to be considered in determining the geographic extent of the area within which annoyance at aircraft overflight is a compatibility concern.

Overflight Altitude

Single-event noise levels are often promoted as useful in identifying the existence of noise concerns in locations beyond those typically outlined by cumulative noise exposure contours. A less problematic alternative is to use the altitude of aircraft overflights (their height above ground level) as a means of defining the limits of these additional concerns. At least for general aviation airports, experience suggests a correlation between frequent, low-altitude aircraft overflights and noise-related annoyance.

Other Noise Compatibility Measures

Although not applicable as the primary basis for formulation of noise compatibility policies, certain other noise compatibility measures can play important secondary roles in the determination of noise level acceptability.

Interior Noise Levels

For many land uses, interior noise levels resulting from exterior noise sources are equally, if not more, important than exterior noise levels as a determinant of acceptability. Furthermore, interior noise level criteria together with data and assumptions regarding the noise level reduction (NLR) provided by the structure can be combined to indirectly indicate a maximum acceptable level of exterior noise.

Factors Affecting Interior Noise Level Criteria

Various human factors play a part in determining acceptable interior noise levels. For residences, the most important are usually considered to be speech interference and sleep disruption. As noted earlier in this chapter, speech interference begins to become a problem when steady noise levels reach approximately 60 to 65 dBA. For sleep disruption, the threshold of significance is less absolute in that there is more variability from one person to another. Nevertheless, the indication from several studies is that the noise threshold for significant occurrence of sleep disruption is higher than for speech interference (only 10% of people are awakened at SEL 80 dB).

One of the choices involved with setting interior noise level criteria is deciding the appropriate noise metric to apply. As apparent from the preceding paragraph, speech interference and sleep disruption are usually measured in terms of either constant or single-event noise metrics. However, for the purposes of land use or building design criteria, cumulative noise exposure metrics are the easiest to implement in that exterior noise is most often measured in these terms. Additionally, once any two of the variables—interior noise level, exterior noise level, or the NLR value of the structure—are known, the third can be directly calculated through simple addition or subtraction. The problem which arises is that, although there is a general relationship between single-event and cumulative noise metrics, it is not constant from one airport to another.

Some airport land use commissions have adopted peak noise level criteria for *intermittent* noises. However, as with any single-event metrics, application of these criteria poses questions in defining the number of events considered to be significant.

Regardless of these issues, cumulative noise exposure metrics are the most commonly used for interior noise level standards, at least for residential uses. In particular, an interior noise level standard of CNEL 45 dB is typical. Allowing for at least 20 dB of noise level reduction from the structure with windows closed, this standard equates to an exterior noise level of CNEL 65 dB. Of particular significance within California, the previously cited California Building Code sets a CNEL of 45 dB as the maximum acceptable interior noise level for residential uses (other than detached single-family dwellings). Although guidelines for other uses exist, there are no other federal or state interior noise level regulations.

Problems arise with developing interior standards for other building uses because some are used only occasionally and others (such as concert halls) are especially sensitive to peak noises. Once again, the issue is whether a cumulative noise exposure metric is the most appropriate basis for compatibility standards.

As noted previously, one such guideline is a L_{eq} 45-dB noise level which the FAA considers as the "usual design objective" for sound insulation of schools. (FAA Order 5100.38A)

Sound Insulation Requirements

Once interior noise level criteria have been established and the exterior noise levels at a particular location are known, the variable which remains is the amount of noise level reduction which the structure needs to provide. Ideally,

Table 7D is offered here as a very general guide to the overall Noise Level Reduction afforded by average types of building construction. Table 7E provides some additional information regarding sound insulation programs for airport area land uses.

Given the noise level reduction provided by standard residential construction, interior noise level standards can generally be satisfied without the need for special sound insulation measures in locations where the exterior noise exposure is less than CNEL 60-65 dB.

DEPT. OF TRANSPORTATION GUIDANCE

Rather than accepting the use of sound insulation as a mitigation action, ALUCs primary objective should be to prevent development of land uses which are basically incompatible with the noise conditions.

As indicated in Chapter 3, installation of sound insulation—whether funded by airports as mitigation for noise impacts or set by ALUCs as a condition for approval of new development—should be accompanied by dedication of an avigation easement to the airport.

Also important to remember is that, even where sound insulation may make a high level of noise exposure acceptable, high-intensity land uses may be unacceptable because of safety factors. This topic is addressed in Chapters 8 and 9.

land uses should not be situated where special measures to insulate the building interior from outside noise would be required. Frequently, though, attainment of this ideal is not realistic either because the development already exists or because the need for development warrants the special measures.

The objectives of sound insulation programs are to provide a meaningful reduction in aircraft noise inside homes and schools and to satisfy the interior noise standard of CNEL 45 dB. For schools, the interior noise standard is usually assumed to be an hourly L_{eq} of 45 dB during the peak period of aircraft operations during school hours. It is also usually assumed that a meaningful degree of noise reduction is attained when the interior noise level is reduced by 5 dB more than otherwise provided by the structure. These standards are consistent with FAA guidelines which apply when federal funds are used for the sound insulation program.

Older homes in good repair may be expected to provide aircraft noise reduction of about 20 to 30 dB with the windows and doors closed. Newer homes constructed to meet current energy-conserving building codes can provide 25 to 30 dB aircraft noise reduction. This means that many homes will meet the CNEL 45 dB interior noise standard in an aircraft noise environment up to CNEL 65 dB without additional acoustical treatment, assuming that windows and doors are closed. (As indicated above, this factor is one of the bases for the selection of the CNEL 65 dB exterior noise standard.) If the windows are partially opened, most homes will provide no more than 15 to 20 dB noise level reduction, regardless of age or construction practices.

Interior Noise Level Criteria in Land Use Compatibility Planning

Installation of special sound insulation in structures is often thought to be broadly suitable as a land use compatibility measure for highly noise-impacted locations. It should not be viewed that way, however.

The most appropriate application for structural sound insulation is for existing land uses. It is a method of improving existing incompatible conditions when changing the land use to something less noise sensitive is not practical. Even then, though, there are limitations. Sound insulation is not effective for land uses in which noise-sensitive activities take place outdoors. Unlike the case with ground-based noise sources, sound walls and other such devices do nothing to block noise from aircraft while they are in the air.

With regard to new development, sound insulation should be regarded as a measure of last resort. It is not a substitute for good land use compatibility planning in the first place. Exterior noise levels should generally be the primary consideration in evaluation of proposed land uses, especially residential development and other land uses where noise-sensitive outdoor activities are normal and important features.

For those airports where noise exposure levels and the demands for land use development dictate the use of sound insulation, airport land use commissions have the authority to establish definitive policies. State airport land use commission statutes (Public Utilities Code, Section 21675(a)) specifically

Construction Type	Typical Occupancy	General Description[a]	Noise Level Reduction (NLR)[b] in dB
1	Residential, Commercial, Schools	Wood framing. Exterior stucco or wood sheathing. Interior drywall or plaster. Sliding glass windows. Windows partially open.	15–20
2	Same as 1 above	Same as 1 above, but windows closed.	25–30[c]
3	Commercial, Schools	Same as 1 above, but windows are fixed ¼-inch plate glass.	30–35
4	Commercial	Steel or concrete framing. Curtain-wall or masonry exterior wall. Fixed ¼-inch plate glass windows.	30–40

Notes:

[a] Construction methods assume no special control provisions.

[b] The NLR range depends upon the amount that windows are open, the degree of seal, and the window area involved.

[c] For older homes in good repair, the NLR is typically 20–30 dB with windows and doors closed.

Source: Paul S. Veneklasen & Associates (1973)
Supplemental notes added

TABLE 7D

Noise Reduction Afforded by Common Building Construction

The California requirements for, and FAA funding of, sound insulation programs apply only to civilian airports. Although similar measures might be appropriate with respect to military airfields, the U.S. military does not have legal authority to insulate civilian structures.

note that ALUCs may "determine building standards, including soundproofing" when developing airport land use compatibility plans. ALUCs have mostly steered clear of setting detailed building standards, however.

Those that deal with the question of acceptable indoor noise levels typically use one of two approaches. One method is to indicate the noise level standards for various indoor building uses and require project proponents to show how those standards will be met. Another common approach is for the ALUC to establish criteria specifying the amount of Noise Level Reduction a building in a particular noise environment must provide. Again, the details of how the criterion is met are left to the proponent.

In light of these factors, ALUCs contemplating establishment of interior noise level criteria are advised to:

- Consider whether such criteria are necessary (in general, standard construction will provide adequate noise level reduction in areas where exterior noise levels are below CNEL 60 to 65 dB);
- Limit the applicability to residences, schools, and other equally noise-sensitive land uses; and
- Base the criteria on the CNEL metric unless data to support other measures can be documented.

Buyer Awareness Measures

In a pure sense, the acceptability of a given noise level with respect to a particular type of land use should solely be a function of the noise level and the land use. In practice, however, judgments of acceptability are easier to make at high noise exposure levels than at lower ones. At high noise levels, clear evidence exists that human activities associated with certain land uses will be disrupted and many people will be highly annoyed. Accordingly, community policies can be adopted to preclude these land uses under most circumstances.

At lower noise levels, the variability in how people react becomes more of a factor. In these lower noise environments—whether the threshold is at CNEL 65, 60, or even 55 dB—relatively few people are expected to be highly annoyed and the majority will probably not be even moderately annoyed. Total prohibition of certain types of land uses, especially residential land uses, consequently may not be necessary. More important is to give people who may be annoyed by airport noise timely information with which to assess how living in an airport vicinity would affect them. For these situations, buyer awareness measures such as those described in Chapter 3 can be effective strategies.

Noise and Assessment of Airport Development Impacts

In most of the circumstances previously discussed in this chapter the intent is to determine land use compatibility relative to known or projected airport noise levels. A much different context within which local assessment of airport noise impact acceptability also occurs is when airport facility improvements

Typical Insulation Measures

The primary path of aircraft noise into buildings is usually through the windows, so the acoustical performance of buildings is strongly dependent upon the type, location, and size of windows. If the windows are acoustically treated, then other building components become acoustically significant. For this reason, sound insulation programs almost always include replacement of standard windows and doors with acoustically-rated assemblies. In addition, most programs include insulation of attic spaces, and sealing or baffling of openings and vents to limit the effects of other common building elements on the interior noise levels. Fireplaces may also be treated with chimney cap dampers or glass doors. The use of these measures can provide up to 35dB aircraft noise reduction.

Note that the use of acoustically-rated windows and doors assumes that the windows and doors can be maintained in a closed configuration, which presumes that some means of providing adequate fresh air exchange is provided to meet the requirements of the Uniform Building Code. For this reason, most aircraft sound insulation programs include modifications of the ventilation system to ensure fresh air circulation. In some cases, air conditioning will be required, though it is not usually possible to obtain federal funding to provide that feature.

Practical factors usually limit sound insulation programs to the above measures, though the presence of acoustically weak building elements may still preclude satisfying the interior noise standards under extreme conditions.

For example, exterior walls of wood siding may allow more aircraft noise to pass through them than will pass through acoustically-rated windows, a function of both the transmission loss characteristics of the wall materials and the total surface area of the walls as compared to the windows. The only practical means of significantly increasing the transmission loss of wood siding walls is to mount the interior wall surfaces on resilient channels, which requires removing all of the affected wall surfaces. This is obviously impractical so, in this case, the wood siding exterior wall becomes the limiting factor in the acoustical performance of the building facades. For all homes, there is no practical value to increasing the acoustical ratings of windows beyond the rating of the wall assembly.

In some homes, the roof/ceiling assembly may be a single composite layer, with no attic space. Such an assembly is typically weak from an acoustical standpoint, and may be the dominant source of aircraft noise transmission into the room. Practical treatment of this assembly is also limited to removing the ceiling panels and re-mounting them on resilient channels, provided that there is an air space of about 2 to 4 inches available between the ceiling and the roof panels. This measure is usually impractical, so the roof/ceiling design may also limit the effectiveness of other acoustical treatments.

Testing and Implementation

If federal funds are used for sound insulation programs, acoustical testing is required to ensure that the program objectives have been satisfied. FAA guidelines require that at least 10% of homes be acoustically tested before and after the acoustical treatment program to demonstrate that the desired noise reduction values have been achieved. The noise measurements are usually performed on a single-event basis during actual aircraft overflights, though simulated aircraft noise is sometimes played from loudspeakers through building facades in areas where it is difficult to arrange testing during overflights. The disadvantage of using simulations is that it is usually not possible to acoustically excite the entire building as would occur during an aircraft overflight.

Because of the scope of sound insulation projects, which include public relations, program management, construction management, architectural design, and acoustical testing, many airports retain a design and implementation team. Program management is sometimes provided by the airport, but the architectural and acoustical services are usually assigned to outside consultants. Total program costs can be very high, as the treatment costs per home can range from about $5,000 to $25,000, depending upon the treatments required, and the value of the home.

TABLE 7E

Sound Insulation Programs

On this topic, two things are important to note:

- Not all airport development necessarily results in increased noise impacts; and
- Noise can increase as a result of additional aircraft operations even in the absence of new airport development.

As discussed in Chapter 4, state law requires that ALUCs review certain types of airport development plans. This requirement also applies to development plans for public or special-use heliports such as those located at hospitals.

or changes in airport usage patterns are proposed. Unlike the assessment of land use development proposals where the concern is with incompatible uses encroaching on the airport, this situation involves concerns that airport construction or other changes could adversely impact existing land uses.

In general, the noise impacts of airport development can be evaluated against the same criteria as applies to land use development. A question which might be asked is: are there nearby existing or planned land uses which would be considered incompatible with the airport if the latter were already in existence? If so, then actions to mitigate the impacts of the airport development are appropriate.

Another factor with regard to assessment of airport development is that consideration needs to be given not just to the absolute level of noise, but also the amount of noise increase resulting from the project. As a guideline for considering when noise level changes might be significant and thus require thorough environmental impact review, the FAA has established a screening criterion. In noise-sensitive locations where the DNL/CNEL already exceeds 65 dB, an increase of 1.5 dB is deemed the threshold of potential significance (FAA–1986). (Although it can be argued that *any* increase in locations already subject to more than DNL/CNEL 65 dB should be considered unacceptable, the fact of the matter is that a change of 1.5 dB is not perceptible outside of a laboratory setting. Also, 1.5 dB is within both the daily fluctuation and typical degree of accuracy of most noise contours.) The FICON report expands upon this screening concept by recommending that a projected increase of 3.0 dB within an area exposed to a DNL/CNEL of 60 to 65 dB also be subject to analysis and possible mitigation.

Not reflected in these screening criteria is that noise increases of several decibels may also be significant in quieter environments (ones below DNL/CNEL 60 dB). This outcome has become apparent in many parts of the country when the FAA has implemented flight track changes affecting communities which previously had not routinely been subjected to a high volume of aircraft overflights. Substantial community reaction has resulted even though the changes only affected air traffic patterns at altitudes above 3,000 feet and the resulting noise levels were still well below normally acceptable DNL/CNEL levels. (Reactions such as this lend further credibility to the concept of normalization described earlier.)

A final consideration with respect to reviews of airport development proposals is that the issue involves not only a matter of policy (how much noise is acceptable?), but also, as previously noted, communication of the information in a form that the general public can comprehend. Consequently, environmental impact documents prepared for airport-related projects may need to make use of supplemental noise metrics to explain the impacts even though the determination of significance relies upon criteria related to cumulative noise metrics.